

## Accepted Manuscript

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PII: S0167-6377(17)30166-9

DOI: <https://doi.org/10.1016/j.orl.2017.11.016>

Reference: OPERES 6312

To appear in: *Operations Research Letters*

Received date: 15 March 2017

Revised date: 27 November 2017

Accepted date: 27 November 2017

Please cite this article as: G. Feng, X. Li, Z. Wang, On substitutability and complementarity in discrete choice models, *Operations Research Letters* (2017), <https://doi.org/10.1016/j.orl.2017.11.016>

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Operations Research Letters 00 (2017) 1–8

**Operations  
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# On Substitutability and Complementarity in Discrete Choice Models

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## Abstract

In this paper, we propose the concepts of substitutability and complementarity in discrete choice models. These concepts concern whether the choice probability of one alternative in a choice model increases or decreases with the utility of another alternative, and they play important roles in capturing certain practical choice patterns, such as the halo effect. We study conditions on discrete choice models that will lead to substitutability and complementarity. We also present ways of constructing choice models that exhibit complementary property.

*Keywords:* discrete choice models, substitutability, complementarity, halo effect, random utility model, representative agent model

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## 1. Introduction

In this paper, we propose and study the concepts of substitutability and complementarity in discrete choice models. Discrete choice models are useful tools to model choices made by individuals when facing a finite set of alternatives. For instance, they can be used to model consumers' choices among a set of products, passengers' choices among a set of transportation modes, and many other choice scenarios. Because of the adaptability, flexibility and analytical convenience, discrete choice models have gained a lot of attention in the economics, marketing, operations research and management science communities in the last few decades. In particular, such models have been used as the underlying behavioral model for many operational decision-making problems, such as transportation planning, assortment optimization, multi-product pricing, etc.

A variety of discrete choice models have been proposed in the literature. In this paper, we focus on those that map a vector of utilities of each alternative to a vector of choice probabilities. Many important classes of discrete choice models take such a form, including the random utility models, the representative agent models, and the recently proposed welfare-based choice models [1]. We will provide a more detailed review of these models and their relations in the end of this section.

In this paper, we define two useful properties in choice models — *substitutability and complementarity* — and study how such properties can be reflected in choice modeling. The two properties concern whether the choice probability of one alternative will increase or decrease when the utility of another alternative increases. We show that the random utility models only allow substitutability between alternatives. However, in certain applications, it is desirable to allow some alternatives to exhibit complementarity, in order to explain certain phenomenon observed

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